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Comparing the plug-in gait model output to an individually scaled musculoskeletal model using an extensive normative data set

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Introduction: Studies have compared walking gait of children to that of adults or between certain age groups, i.e., elderly versus younger adults (e.g., Bleyenheuft & Detrembleur, 2012). Comprehensive reference data bases are hampered by variable marker sets and inter-tester variability being inherent issues (McGinley et al., 2009).
The purpose of this study was to provide a consistent database of healthy controls from childhood to the elderly to be used in clinical studies at our center. Secondly, results obtained from an established gait model were compared to an individually scaled musculoskeletal model.

Methods: A total of 195 subjects, aged from 6 to 86 years, were recruited. Kinematic and kinetic data were recorded by a Vicon system (612, 8 cameras, Vicon, Oxford, UK) in a gait laboratory. Six trials at preferred walking speed were recorded. The Vicon gait marker protocol was used and processed using the plug-in gait (PIG). Additionally, raw data were exported and processed in the AnyBody Modelling System (AMS, AnyBodyTech, Aalborg, DK) using an optimization and scaling algorithm. Age groups were compared by ANOVA and correlations with age and selected anthropometric parameters were performed. Results between models were compared by paired t-tests.

Results: No age dependency of some selected kinematic parameters such as knee angle at TD or the amount of knee flexion during stance was found. Walking velocity did only vary minimally with age while cadence was increased in children compared to all adult age groups. Across all subjects, a significant correlation of leg length and cadence was observed. Integrated ankle joint power increased with age while hip work peaked at age 25 years. Model comparisons revealed off-sets between discrete kinematic parameters while ranges of motion were comparable. This also applies to net joint kinetic parameters. Individual muscle forces or muscle work were not extracted from the PIG calculations but only from the scaled model.

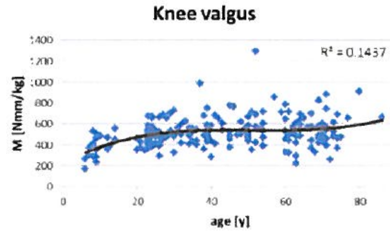

Figure 1: Maximum knee valgus angle during stance vs. age; polynomial fit, p > 0.05.

Discussion and Conclusion: In summary, gait velocity was highly consistent despite the fact that subjects chose their preferred walking speed. In healthy subjects, gait kinematics remains reasonably constant over a large age range. There are, however, shifts in total joint work which were opposite to data reported by Karamanidis & Arampatzis (2005). Musculoskeletal models allow for a more detailed analysis of changes in particular muscle groups which correlated well to previous results. It is therefore expected that the inclusion of individualized musculoskeletal models into standard clinical gait analysis will allow for enhanced understanding of alterations in gait function.

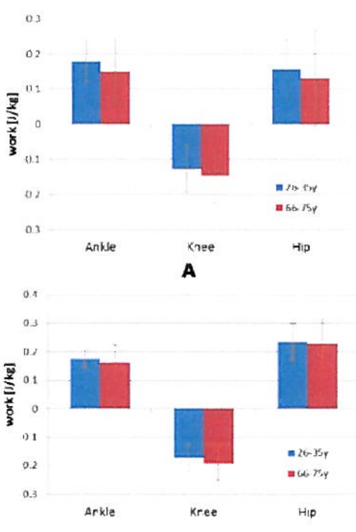

Figure 2: Comparison of total joint work per gait cycle for two age groups. A: Plug-in gait; B: AnyBody Modeling System.

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